Guided Self-organisation in Learning Networks as a Means to Optimize Cognitive Load and Transfer of Information Seeking Skills

Goals

Learning Networks (LNs) are designed to support the lifelong learner. In such settings, learning needs to be guided for self-organizational processes to emerge. We first use a cognitive load approach to argue that without guidance, learners have to allocate cognitive capacity to structuring the collaborative process of knowledge sharing, thus diminishing the capacity available for knowledge sharing and learning. Then in the domain of online information-seeking, we investigate whether peer-tutoring can be used as guidance and how peer-tutoring is modulated by the distance in tutee-tutor expertise levels. Finally, we conduct a design-experiment to fine-tune the technical infrastructure needed to guide selforganisation.

Background and problem definition

Learning Networks (LNs) are particularly suitable for the lifelong learner who works towards continuous competence development. The lifelong learner is self-directed, decides what, when and how to learn. In a traditional setting a teacher primarily selects learning activities and dishes out knowledge, in LNs, the focus becomes more on the students' learning processes. In the online social networks, which constitute LNs, the role of the teacher needs to change. Teachers are expected to give up their role as 'knowledge transmitter' and 'coach' the students' individual learning processes. However, students have to adjust to the philosophy of LNs too. They are expected to take up responsibility for the organisation of their own learning activities and for sharing knowledge with their peers. Little research has been conducted into how this may be achieved best. This proposal seeks to address that question.

As indicated, it is essential to the success of the LNs that students become active, self-directed learners, and eager knowledge-sharers. Only by adopting these roles, students can acquire the skills that are needed ultimately to become lifelong learners. From a functional point of view, a Learning Network (Koper, Rusman, & Sloep, 2005; Koper & Sloep, 2002; Sloep, 2008) is an online social network, designed to support non-formal learning in a particular domain. The network is composed of a group of people who use learning resources to learn together at the time, place, and pace that suits them best in ways appropriate to the task (Harasim, Hiltz, Teles, & Turoff, 1995). LNs may be set apart from other, functionally similar devices such as virtual learning environments, bulletin boards and fora in that they are self-organising.

This does not mean that social interaction and learning is supposed magically to occur. Rather it emphasizes that the social structures that are conducive to or even needed for learning, emerge on top of a responsive, sophisticated, yet non-imposing technical infrastructure. This infrastructure is designed to support a variety of social structures, allowing the network participants leeway in developing their own preferred modes of interaction. The infrastructure, specifically the boundary conditions it sets, hence guide self-organisation.

Students in LNs should not only fend for their own learning activities, but also share knowledge with their peers. Every student is expected to solve questions, give advice, participate in discussions, etc. Students thus are participants of a social structure. Whether shifting the responsibility for engaging learning activities and sharing knowledge from teachers to the students, has a net beneficial effect depends on how apt students are at self-directing their learning and knowledge sharing. We want to investigate the new role of students as knowledge sharers in LNs by using cognitive load as a common currency. Cognitive load theory (CLT: Paas, Renkl, & Sweller, 2003, 2004; Sweller, 1988) assumes that learning works best under instructional conditions that are aligned with the human cognitive architecture.

In the present context, this means that individual learners only learn effectively if the architecture of their cognitive system, the characteristics of the task and the technical infrastructure are understood, accommodated, and aligned. We believe that CLT offers us the means to describe and gauge both the beneficial and the detrimental effects of students' participation in LNs.

CLT distinguishes three types of cognitive load. The load is called intrinsic if it is imposed by the number of information elements in a learning task and their interactivity. If it is imposed by the manner in which the information is presented to learners and by the learning activities required of learners, such as actively participating in LNs, it is called either extraneous or germane. Whilst extraneous load is imposed by information and activities that do not directly contribute to learning, germane load relates to information and activities that do foster learning processes. Intrinsic, extraneous, and germane load may be added up. Furthermore, if learning is to occur the total load cannot exceed available memory resources (see, Paas, Tuovinen, Tabbers, & Van Gerven, 2003). Intrinsic load constitutes a 'base' load that is reducible only by constructing additional schemas or automating previously acquired schemas, i.e., by an increase in expertise. Only working memory capacity that remains 'unused' by intrinsic load activities, can be allocated to extraneous and germane load. The latter can work in tandem. So a reduction in extraneous load by using a more effective instructional design can free capacity for an increase in germane load.

To support non-formal learning, the learning environment is inherently different than the formal learning settings. We first describe the different learning environment of LNs before we apply CLT to examine whether the non-formal learning environment of LNs suits the collaboration process for knowledge sharing. In the formal learning settings, there are fixed curricula and the social environment is formalized by institutionalized norms and rules. The teacher organizes the learning activities based on the institutional objectives and helps to construct and maintain the social environment where students can acquire knowledge from the teacher or from their peers. In LNs, it is difficult to rely on the teaching staff to cater for the diverse learning needs and individualized learning objectives of self-directed learners. Therefore, learners have to organize their own learning activities and share knowledge with others by constructing their own social interactions in LNs. Moreover, LNs are online social networks where learners do not come in cohorts or classes. These two features make LNs a different learning environment than the formal learning settings. The first question is thus whether learners can construct social interactions, namely collaboration, to share knowledge in this different environment of LNs where there is no guidance for self-directed non-formal learning.

Methodology

The conception paper, *Using peer tutoring to optimize knowledge sharing in Learning Networks: A cognitive load perspective (submitted)*, has been formulated based on the literature review from the fields of non-formal learning, cognitive load theory and collaborative learning. In this conception paper, we described the new learning paradigm of non-formal learning in the different learning environment of LNs and we also explained why knowledge sharing in LNs becomes inevitable when there is no teacher to transmit knowledge. Based on CLT, we examined why the learning environment of LNs causes cognitive overload during the knowledge sharing process on complex learning actions (see the next section of Current status). Furthermore, we proposed peer-tutoring (PT) as a structure that supports knowledge sharing to prevent cognitive overload and help learners benefit from each other during the collaboration process.

Following the conception paper further, four research questions and hypotheses are formulated and these hypotheses will be tested by four sequential experiments.

Experiment 1

Research question

Without a structure that supports knowledge sharing, does the learning environment of LNs cause cognitive overload when learners work on complex learning actions?

Hypothesis

Without a structure that supports knowledge sharing, the learning environment of LNs causes cognitive overload when learners work on complex learning actions with detrimental effects on learning effectiveness and learning efficiency; this does not occur on simple learning actions.

Experiment 2

Next, we propose PT as a support structure to guide the collaborative knowledge sharing process on complex learning actions based on two reasons. First, a peer tutor selection mechanism helps decrease the extraneous load caused by finding a relevant knowledge sharer. Second, the role specifications and interaction structures of PT help learners to get cognitive benefits from each other and to share the high intrinsic load of the complex learning actions during the knowledge sharing process. These two features of PT can thus reduce the possibility of cognitive overload.

Research question

Can a structure of PT that supports knowledge sharing reduce the possibility of cognitive overload on complex learning actions in LNs?

Hypothesis

A structure of PT that supports knowledge sharing reduces the possibility of cognitive overload on complex learning actions in LNs, with beneficial effects on learning effectiveness and learning efficiency.

Experiment 3

If using a PT support structure indeed reduces the possibility of cognitive overload in LNs, the next is to find out how to optimize PT to improve learning performance based on different learning goals. The third experiment is to investigate whether the greater distance between the tutor's expertise and the tutee's expertise will lead to the higher transfer reached by the tutees.

Research question

Does the transfer that is achieved vary as a function of the distance in expertise levels between tutor and tutee?

Hypothesis

The greater the distance between the tutor's expertise and the tutee's expertise, the higher the transfer can be achieved by the tutees.

Experiment 4

Based on the evidence that PT can prevent cognitive overload as well as learning processes and learning outcomes (transfer performance) do vary as a function of the distance in expertise between tutor and tutee, then much is to be gained from a (technical) infrastructure that fosters knowledge sharing through the formation of optimal tutee-tutor pairs.

Research question

How to develop an infrastructure in LNs to dynamically match tutors and tutees on the basis of their expertise levels to achieve a high learning effectiveness and learning efficiency?

Hypothesis

In LNs, an infrastructure that dynamically matches tutees and tutors on the basis of their levels of expertise and the learning goals to be achieved, best supports effective and efficient learning.

Current status

In the conception paper, we examined whether the learning environment of LNs meets the three conditions for achieving successful online collaborative learning (Dillenbourg & Schneider, 1995): group composition, communication media and task features from the perspective of CLT. With regards to group composition, learners in LNs are heterogeneous: they are likely to have different learning goals, academic backgrounds, competency levels and experiences, as well as knowledge about the learning topics. In an online social environment, learners in LNs do not know each other and they do not have a common learning history (Berlanga, Rusman, Bitter-Rijpkema, & Sloep, 2009). Consequently, the heterogeneous group composition imposes learners extraneous load because they are forced to allocate extra cognitive resources in finding a relevant collaborator: they first have to explore the different social environment of LNs, to interact with others and finally to find out who the relevant collaborators are. These activities are not directly related to the learning process of knowledge sharing.

Concerning communication media, LNs are online social networks where learners rely mostly on online communication to interact with others. Online communication that can be either synchronous or asynchronous is different than direct face-to-face communication. In face-to-face communication settings, a speaker can anticipate the needs of the recipient, get feedback on whether the recipient receives and understands the information as well as check whether the recipient agrees with the speaker or not through both verbal and non-verbal messages (Kiesler, Siegel, & McGuire, 1988). In online communication, some of these features are missing and this leads to difficulties in finding a common basis for mutual understanding (Cress & Hesse, 2006). Moreover, for synchronous online communication, two learners need to meet at the same time and this requires extra planning; for asynchronous online communication, learners have to verbalize their thoughts into written texts. Both finding a common basis of mutual understanding and online communication media impose learners extraneous load to do extra cognitive processing that is not directly related to knowledge sharing. To sum up, heterogeneous group composition and online communication impose extraneous load on learners because extra cognitive resources are used in finding a relevant collaborator and finding out how to communicate with others online. These would diminish the cognitive capacity available for knowledge sharing itself.

The third condition, task features, we refer to task complexity in this proposal. To distinguish from “tasks” in formal learning settings, we name the real-life questions and problems, and learning materials and activities which self-directed learner want to deal with in LNs “learning actions”. Learning actions are defined as “any type of resources or events that help learners to acquire a competence” (Berlanga, 2007). These learning actions also vary in complexity. According to CLT, task complexity depends on element interactivity (Sweller, 2006). A task is complex if many elements interact and they cannot be understood in isolation; a task is simple if few elements interact or elements can be understood and learned independently of each other. Levels of element interactivity determine levels of intrinsic load and human WM can only simultaneously process a limited number of interacting information elements (Paas, Renkl et al., 2003; Sweller, 2006).

In LNs, learners take learning actions to achieve their learning goals, for example, seeking online information. This action can be simple or complex: it depends on the element interactivity. A learner may seek online information on one single topic such as looking for the definition of non-formal learning. This simple learning action requires WM to process only one information element at the same time and thus the intrinsic load is low (e.g., seeking resources in a search engine, Google, Wikipedia, etc.). Also, a learner may seek online information on several related topics to find answers about an integrated theme, for example, why does non-formal learning suit lifelong learners? This complex learning action requires WM to simultaneously process several interactive information elements: to find out the definitions of these two topics and the reasons why they are related to each other as well as make judgement from the relationship between these two topics to explain why. To complete the learning action, it is not only necessary to deal with individual elements included but also the interactivity that coexists.

When working on simple learning actions, a learner’s WM only has to process non-interacting elements or a few interacting elements at the same time. Based on the low intrinsic load, she can accomplish simple learning actions by herself within her WM capacity. But sometimes, a learner does have to collaborate with others to share knowledge in order to perform the simple learning actions, for example, when she cannot find answers by herself. In this case, extraneous load that is caused by collaboration in LNs will be imposed on the learner's cognitive system as well. For simple learning actions, however, the total cognitive load remains within the limits of WM capacity because of the low intrinsic load of these actions.

When working on complex learning actions, a learner's limited WM has to process many interacting elements at the same time because of the high intrinsic load. To have more cognitive resources, it is likely that she turns to collaborating with others to share knowledge. However, the different social environment of LNs imposes extraneous load on the learner's cognitive system. Together with the high intrinsic load of complex learning actions, the total cognitive load easily exceeds the limits of the learner's WM capacity, resulting in cognitive overload.

Discussion questions: Methods in the first experiment

In this section, we want to pose three questions that we currently confronted for preparing the first experiment. In the first experiment, we would like to know whether the learning environment of LNs causes cognitive overload on complex learning actions. To answer this question, we assume that learners are guided by the teacher to learn in the formal learning settings while there is no such guidance in LNs. We plan to use a two-way factorial design in this experiment and the two independent variables are learning environment (formal versus non-formal) and complexity of learning actions (simple versus complex). However, the formal learning settings can be either traditional classrooms or an online distance learning classroom. Which one should we include in the experimental design?

Next, from the theoretical review, we assume that cognitive overload will only occur when learners work on complex learning actions; this does not occur on simple learning actions. Therefore, an interaction effect is predicted between two independent variables: learning environment and complexity of learning actions. To test our hypothesis, learners in the cells of working on simple learning actions also have to share knowledge with others. What kind of simple learning actions suit for knowledge sharing in LNs?

To know whether someone is cognitive overload, we first have to measure cognitive load imposed on the learner's cognitive system. People can report their perceived mental burden on the rating scale (Paas, 1992) ranging from 1 (very, very low mental effort) to 9 (very, very high mental effort) . How to implement this rating scale? Should it be implemented after each sub learning action to get an average value of cognitive load or after all sub learning actions to get one value of cognitive load for the whole learning action?

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